CLIMATE AND CROP SERVICE.

By JAMES BERRY, Chief of Climate and Crop Service Division.

The following extracts relating to the general weather conditions in the several States and Territories are taken from the monthly reports of the respective sections of the Climate and Crop Service. The name of the section director is given after each summary.

Precipitation is expressed in inches and temperature in degrees Fahrenheit.

Alabama.—The mean temperature was 46.9°, or about normal; the highest was 76°, at Elba on the 23d, and the lowest, 20°, at Gadsden on the 11th and at Valleyhead on the 13th. The average precipitation was 4.68, or 0.52 above normal; the greatest monthly amount, 11.54, occurred at Newton, and the least, 2.46, at Decatur and Madison.

The month was mild and generally favorable for farm work.—*F. P. Chaffee.*

Arizona.—The mean temperature was 48.2°, or about normal; the highest was 92°, at Champies Camp on the 11th, and the lowest, 7° below zero, at Flagstaff on the 31st. The average precipitation was 0.03, or 1.05 below normal; the greatest monthly amount, 0.60, occurred at Vail, while none fell at a great number of stations.—*W. G. Burns.*

Arkansas.—The mean temperature was 44.9°, or 1.8° above normal; the highest was 82°, at Ione on the 17th and at Bee Branch on the 18th, and the lowest, 10°, at Mossville on the 31st. The average precipitation was 2.76, or 1.54 below normal; the greatest monthly amount, 8.28, occurred at Dallas, and the least, 0.46, at Arkansas City.

The moderate temperature and good rains were beneficial to winter wheat; the stand of early sown was exceptionally good for December, but late sown, while looking fair, was not doing so well. Many fields of early sown were infested with hessian fly.—*E. B. Richards.*

California.—The mean temperature was 47.3°, or 0.8° above normal; the highest was 90°, at Irvine on the 1st, 3d, and 7th, and the lowest, 25° below zero, at Bodie on the 31st. The average precipitation was 1.68, or 2.36 below normal; the greatest monthly amount, 12.31, occurred at Upper Mattole, while none fell at 37 stations.—*A. G. McAdie.*

Colorado.—The mean temperature was 29.3°, or 3.1° above normal; the highest was 78°, at Blaine on the 27th, and the lowest, 32° below zero, at Walden on the 31st. The average precipitation was 0.28, or 0.55 below normal; the greatest monthly amount, 1.30, occurred at Santa Clara, and the least, trace, at a number of stations.—*F. H. Brandenburg.*

Florida.—The mean temperature was 58.9°, or 0.6° below normal; the highest was 89°, at Miami on the 13th and at Lake Butler on the 31st, and the lowest, 26°, at St. Francis and Sumner on the 26th. The average precipitation was 4.52, or 1.90 above normal; the greatest monthly amount, 8.27, occurred at Carrabelle, and the least, 0.69, at Key West.—*A. J. Mitchell.*

Georgia.—The mean temperature was 46.9°, or 1.2° below normal; the highest was 80°, at Waycross on the 23d, and the lowest, 19°, at Dahlonega on the 11th. The average precipitation was 5.63, or 2.18 above normal; the greatest monthly amount, 10.90, occurred at Fort Gaines, and the least, 2.76, at Waycross.

The general effect of the weather was highly beneficial to fruit and agricultural interests. The absence of any warm periods prevented the flow of sap in fruit trees, and the conditions of orchards throughout the State is considered good. Winter wheat has come up to fine stands and is growing well.—*J. B. Marbury.*

Idaho.—The mean temperature was 31.1°, or 4.8° above normal; the highest was 58°, at Payette on the 20th, and the lowest, 34° below zero, at Swan Valley on the 31st. The average precipitation was 1.48, or 0.24 below normal; the greatest monthly amount, 5.53, occurred at Moscow, and the least, 0.10, at Downey.—*S. M. Blandford.*

Illinois.—The mean temperature was 32.2°, or 1.2° above normal; the highest was 66°, at Greenville on the 2d and at St. John on the 22d, and the lowest, 3° below zero, at Kishwaukee and Riley on the 31st. The average precipitation was 0.93, or 1.22 below normal; the greatest monthly amount, 2.90, occurred at Cobden, and the least, 0.02, at Bushnell.

The weather was generally favorable. Wheat was generally in good condition, with the exception of some damaged by hessian fly in the central and southern portions.—*M. E. Blystone.*

Indiana.—The mean temperature was 33.2°, or 0.4° above normal; the highest was 73°, at Boonville on the 23d, and the lowest, 2° below zero, at Bluffton on the 11th. The average precipitation was 1.20, or 1.35 below normal; the greatest monthly amount, 3.10, occurred at Mount Vernon, and the least, 0.01, at Winamac.

Mild and dry weather prevailed during the month and fields were without snow covering. Rye and wheat looked green, and in the southern portion made good growth. The hessian fly injured early-sown wheat in many localities. Much plowing was done during the month and farm work in general was well advanced. More corn fodder was shredded than in previous years. Live stock is fat and in good condition.—*C. F. R. Wappenhans.*

Iowa.—The mean temperature was 26.9°, or 3.3° above normal; the highest was 62°, at Albia on the 23d, and the lowest, 10° below zero, at Primghar, Sibley, Sioux Center, and Spirit Lake on the 31st. The average precipitation was 0.45, or considerably below normal; the greatest monthly amount, 2.70, occurred at Vinton, and the least, trace, at Bonaparte, Clear Lake, and Mooar.—*J. R. Sage, Director; G. M. Chappel, Assistant.*

Kansas.—The mean temperature was 35.2°, or 1.9° above normal; the highest was 78°, at Ulysses on the 22d, and the lowest, 15° below zero, at Tribune on the 30th and at Colby on the 31st. The average precipitation was 0.34, or 0.65 below normal; the greatest monthly amount, 0.93, occurred at Campbell, and the least, trace, at Coolidge, Tribune, and Scott.

The mild, dry weather was quite favorable for farm work, and much plowing for spring seeding was done. Wheat continued in fine condition in the central and eastern counties, and was still being pastured to prevent too rapid growth, though that was checked in a measure by the dry weather; in the western counties a long drought stopped growth of wheat and checked germination of seed in the soil, but sowing continued through the month.—*T. B. Jennings.*

Kentucky.—The mean temperature was 38.6°, or 0.7° above normal; the highest was 70°, at Warfield on the 3d, and the lowest, 12°, at Loretto on the 11th. The average precipitation was 2.59, or 0.61 below normal; the greatest monthly amount, 5.86, occurred at Middlesboro, and the least, 1.23, at Scott.

The month as a whole was very pleasant and was favorable to agricultural interests. Reports on winter wheat are very conflicting, especially as to the amount of damage done by the hessian fly. There is no doubt that many fields of early sown wheat have suffered severely from the ravages of the pest, and some of the later fields are affected in a lesser degree; the extent of this damage can not be closely estimated until the spring.—*H. B. Hersey.*

Louisiana.—The mean temperature was 52.2°, or about normal; the highest was 83°, at Lake Providence on the 1st, and the lowest, 23°, at North Louisiana Experiment Station on the 9th. The average precipitation was 5.58, or 1.54 above normal; the greatest monthly amount, 12.69, occurred at Wallace, and the least, 1.35, at Robeline.

Exceptionally favorable weather for farming interests prevailed during the month.—*W. T. Blythe.*

Maryland and Delaware.—The mean temperature was 34.4°, or 1.2° below normal; the highest was 68° at Hagerstown, Md., on the 24th, and the lowest, 2° below zero, at Sunnyside, Md., on the 17th. The average precipitation was 2.43, or 0.29 below normal; the greatest monthly amount, 4.10, occurred at Mount St. Marys, Md., and the least, 1.51, at Clearspring, Md.

The early and middle sowings of wheat are more promising than the late sown, which is rather thin in places. Here and there the fly has worked some damage to early wheat, but not enough to cause any particular apprehension. It has been a remarkable winter for grass thus far, many pastures still affording fairly good grazing at the close of December.—*Oliver L. Fassig.*

Michigan.—The mean temperature was 26.8°, or 1.0 above normal; the highest was 60°, at Plymouth on the 3d, and the lowest, 18° below zero, at Humboldt on the 27th. The average precipitation was 0.76, or 1.45 below normal; the greatest monthly amount, 3.25, occurred at Chatham, and the least, trace, at Birmingham and Port Austin.

The condition of winter wheat did not improve materially during the month. Lack of snow protection most of the month, with alternate freezing and thawing, were detrimental, and at the close of the month the condition of wheat was poor. Correspondents quite generally noted the presence of hessian fly.—*C. F. Schneider.*

Minnesota.—The mean temperature was 18.6°, or 2.0° above normal; the highest was 51°, at Beardsley on the 3d, and the lowest, 45° below zero, at Pokegama on the 31st. The average precipitation was 0.51, or 0.21 below normal; the greatest monthly amount, 1.31, occurred at at Grand Meadow, and the least, 0.06, at Ada.

It is said that in the logging regions enough snow fell on the 24th for the beginning of hauling to be made. Navigation on Lake Superior was open to December 20, with expectation that boats would continue running for some time between Duluth and north shore points of Minnesota.—*T. S. Outram.*

Mississippi.—The mean temperature was 48.3°, or 0.4° below normal; the highest was 78°, at Brookhaven on the 7th and at Leakesville on the 22d, and the lowest, 21°, at Jackson on the 9th. The average precipitation was 4.04, or 0.14 below normal; the greatest monthly amount, 8.76, occurred at Leakesville, and the least, 1.27, at Macon.—*W. S. Belden.*

Missouri.—The mean temperature was 35.8°, or 2.0° above normal; the highest was 68°, at Mount Vernon on the 2d, and the lowest, 3° below zero, at Maryville on the 31st. The average precipitation was 0.72, or 1.47 below normal; the greatest monthly amount, 3.45, occurred at Sikeston, and the least, 0.05, at Sedalia.

It was the driest December during the past thirteen years. In a few of the eastern counties wheat was reported a little thin on the ground, as the result of dry weather at seeding time, and in localities in the east-central and southern counties early sown wheat showed much damage by fly, some fields being practically ruined, but the late sown was generally uninjured, and the crop as a whole was in excellent condition at the close of the month. Fall pastures held out remarkably well, and in many sections comparatively little feeding of stock was necessary.—*A. E. Hackett.*

Nebraska.—The mean temperature was 31.9°, or 5.9° above normal; the highest was 74°, at Benkelman on the 19th and 23d, and the lowest, 25° below zero, at Madrid on the 31st. The average precipitation was 0.31, or 0.37 below normal; the greatest monthly amount, 1.25, occurred at Odell, while none fell at Madrid and Smithfield.—*G. A. Loveland.*

Nevada.—The mean temperature was 33.1°, or about 3.0° above normal; the highest was 71°, at Candelaria on the 4th and 6th, and the lowest, 11° below zero, at Monitor Mill on the 31st. The average precipitation was 0.19, or 1.13 below normal; the greatest monthly amount, 2.05, occurred at Lewers Ranch, while none fell at several stations. It was the driest December during the past twelve years.—*J. H. Smith.*

New England.—The mean temperature was 26.0°, or 1.7° below normal; the highest was 61°, at Middletown, Conn., on the 24th, and the lowest, 28° below zero, at Flagstaff, Me., and Berlin Mills, N. H., on the 17th. The average precipitation was 2.27, or 1.24 below normal; the greatest monthly amount, 4.24, occurred at Enosburg Falls, Vt., and the least, 0.97, at Plymouth, N. H.—*J. W. Smith.*

New Jersey.—The mean temperature was 34.4°, or about normal; the highest was 64°, at Paterson and Salem on the 24th, and the lowest, 2° below zero, at Layton on the 17th. The average precipitation was 2.59, or 0.80 below normal; the greatest monthly amount, 3.97, occurred at Woodbine, and the least, 1.47, at Trenton.—*E. W. McGann.*

New Mexico.—The mean temperature was 35.1°, or 1.0° above normal; the highest was 76°, at San Marcial on the 22d, and the lowest, 15° below zero, at Bluewater on the 31st. The average precipitation was 0.41, or 0. 33 below normal; the greatest monthly amount, 1.15, occurred at Gallinas Springs and White Oakes, while none fell at Gage and Lordsburg.—*R. M. Hardinge.*

New York.—The mean temperature was 26.2°, or 0.8° below normal; the highest was 59°, at Jamestown on the 23d, and the lowest, 25° below zero, at Indian Lake and Jay on the 17th. The average precipitation was 2.38, or 0.71 below normal; the greatest monthly amount, 5.04, occurred at Adams Center, and the least, 0.89, at Ogdensburg.

The month was very favorable for winter grain. In the northeast portion deep snow was continuous, and at the close of the month ample snow protection was general, with but little frost in ground. Full reports showed that wheat and rye were in unusually fine condition, the plant being well rooted, well advanced and showing a healthy color.—*R. G. Allen.*

North Carolina.—The mean temperature was 41.7°, or 0.8° below normal; the highest was 76°, at Newbern on the 4th, and the lowest, 10°, at Linville on the 22d. The average precipitation was 4.50, or 0.76 above normal; the greatest monthly amount, 7.53, occurred at Highlands, and the least, 2.25, at Norfolk.

The condition of winter wheat at the close of the month was very satisfactory; good stands and excellent growth were secured, and late sown came up well. Damage by hessian fly was confined to a very few counties.—*C. F. von Herrmann.*

North Dakota.—The mean temperature was 17.3°, or 4.6° above normal; the highest was 58°, at University on the 20th, and the lowest, 29° below zero, at Jamestown on the 12th and at Dunseith on the 31st. The average precipitation was 0.31, or slightly below normal; the greatest monthly amount, 0.92, occurred at Berlin, and the least, trace, at Ellendale and Falconer.—*B. H. Bronson.*

Ohio.—The mean temperature was 31.6°, or 0.8° below normal; the highest was 65°, at Portsmouth on the 22d, and the lowest, 2 below zero, at Bellefontaine on the 17th. The average precipitation was 1.24, or 1.37 below normal; the greatest monthly amount, 2.46, occurred at Portsmouth, and the least, 0.50, at Circleville.

The weather has been favorable for the growth of wheat during the month, except for a lack of precipitation in some central counties. There was a moderate amount of damage by freezing and thawing. The effect of the work of the hessian fly is apparent in the early sown in nearly all sections. The plants from the later seeded fields are generally short, but show a good stand and healthy color in many sections; in others, on the other hand, both early and late sown are very unsatisfactory. Other winter grains and fruit trees are reported to be in good condition.—*J. Warren Smith.*

Oklahoma and Indian Territories.—The mean temperature was 41.9°, or 2.0° above normal; the highest was 74°, at Colbert on the 26th and at Lehigh on the 27th, and the lowest, 9° below zero, at Kenton on the 31st. The average precipitation was 0.52, or 1.44 below normal; the greatest monthly amount, 1.67, occurred at Bengal, while none fell at Tulsa.

Wheat was in very good condition, making a healthy growth, and was generally pastured. Plowing for spring crops was in general progress and well advanced. Some complaints are made that conditions are becoming droughty.—*C. M. Strong.*

Oregon.—The mean temperature was 42.1°, or 3.5° above normal; the highest was 70°, at Merlin on the 18th and at Prineville on the 24th, and the lowest, zero, at Joseph on the 31st. The average precipitation was 6.46, or slightly below normal; the greatest monthly amount, 27.24, occurred at Glenora, and the least, 0.33, at Newbridge.

The month has been favorable for farming operations, and at the close plowing and seeding were practically finished in all sections. The acreage sown to fall wheat is reported as about the same as last year, except in a few counties in the Willamette Valley, where it has been slightly reduced. The early sown stooled nicely and the fields are generally in a promising condition. But few correspondents report damage by the hessian fly, but fears are entertained that this pest will work more or less injury in the spring. The pastures in the western part of the State remained green through the month.—*E. A. Beals.*

Pennsylvania.—The mean temperature was 31.2°, or 0.7° below normal; the highest was 65°, at Coopersburg on the 24th and at Lancaster on the 25th, and the lowest, 2° below zero, at Smethport on the 17th. The average precipitation was 2.08, or 0.98 below normal; the greatest monthly amount, 4.16, occurred at Somerset, and the least, 0.40, at Chambersburg and Smethport.—*L. M. Dey.*

South Carolina.—The mean temperature was 45.5°, or 1.4° below normal; the highest was 79°, at Gillisonville on the 23d, and the lowest, 18°, at Holland on the 26th. The average precipitation was 5.64, or 2.86 above normal; the greatest monthly amount, 8.15, occurred at Effingham, and the least, 3.64, at Batesburg.—*J. W. Bauer.*

South Dakota.—The mean temperature was 26.3°, or about 4.0° above normal; the highest was 68°, at Chamberlain on the 21st, and the lowest, 19° below zero, at Bowdle on the 30th and at Wessington Springs on the 31st. The average precipitation was 0.19, or 0.24 below normal; the greatest monthly amount, 0.70, occurred at Fort Meade, while none fell at Mitchell.—*S. W. Glenn.*

Tennessee.—The mean temperature was 41.7°, or 1.2° above normal; the highest was 70°, at Dover on the 23d and 24th, and the lowest, 12°, at Rugby on the 12th. The average precipitation was 2.78, or 0.98 below normal; the greatest monthly amount, 4.30, occurred at Benton, and the least, 0.74, at Elk Valley.

Generally favorable weather prevailed and wheat made good growth, although rather small for the season, as most of the crop was sown late. Early-sown wheat was badly injured by the hessian fly, but mostly in the eastern and middle divisions; in the western division the crop was generally promising—*H. C. Bate.*

Texas.—The mean temperature was 50.4°, or about normal; the highest was 90°, at Fort Ringgold on the 22d, and the lowest, 1°, at Amarillo on the 31st. The average precipitation was 1.26, or 0.59 below normal; the greatest monthly amount, 5.72, occurred at Houston, while none fell at Hale Center, Henrietta, and Ira.

The deficiency of rainfall which characterized the month over the greater portion of the State was unfavorable to some while it was favorable to other agricultural interests. Wheat seeding, which was well advanced at the opening of the month, was hurried forward during the first decade with very favorable weather, but absence of rainfall proved unfavorable during the second and third decades, and late-sown wheat did not germinate well; early-seeded wheat came up to good stands and in some places was being pastured. Fall gardening is doing very nicely, and as a result the supply of vegetables is about up to the requirements.—*I. M. Cline.*

Utah.—The mean temperature was 30.6°, or 3.9° above normal; the highest was 68°, at Pinto on the 5th, and the lowest, 27° below zero, at Henefer and Woodruff on the 31st. The average precipitation was 0.14, or 0.85 below normal; the greatest monthly amount, 1.30, occurred at Park City, while none fell at a number of stations. It was the driest December since 1878.—*L. H. Murdoch.*

Virginia.—The mean temperature was 38.1°, or 1.9° below normal; the highest was 73°, at Barboursville on the 13th, and the lowest, 8°, at Dale Enterprise on the 17th. The average precipitation was 2.59, or 0.17 below normal; the greatest monthly amount, 4.25, occurred at Bedford City, and the least, 1.30, at Woodstock.

The growth of early sown wheat has thus far been all that could be desired, except some damage by the hessian fly, which, however, has been slight.—*E. A. Evans.*

Washington.—The mean temperature was 40.3°, or about 5° above normal; the highest was 67°, at Sedro-Woolley on the 10th, and the lowest, 7° below zero, at Northport on the 1st. The average precipitation was 6.30, or 0.83 above normal; the greatest monthly amount, 21.81, occurred at Neah Bay, and the least, 0.40, at Sunnyside.

The mild weather was favorable for winter wheat.—*G. N. Salisbury.*

West Virginia.—The mean temperature was 34.6°, or 0.5° below normal; the highest was 66°, at Weston on the 22d and at Creston on the 25th, and the lowest, 3°, at Terra Alta on the 13th. The average precipita-

tion was 2.26, or 0.54 below normal; the greatest monthly amount, 3.45, occurred at East Bank, and the least, 1.22, at Beckley.

Early sown wheat is reported in excellent condition generally over the State, except in the extreme southern portion, where some damage has been done by the fly. Late sown wheat has been injuriously affected by the freezing and thawing, so that it has not made much progress. Some plowing has been done for corn and stock is looking fairly well.—*E. C. Vose*

Wisconsin.—The mean temperature was 23.5°, or 1.6° above normal; the highest was 52°, at Brodhead on the 22d, and the lowest, 21° below zero, at Grantsburg on the 31st. The average precipitation was 0.71, or 0.88 below normal; the greatest monthly amount, 2.11, occurred at Casco, and the least, 0.07, at Delavan.—*W. M. Wilson.*

Wyoming.—The mean temperature was 28.8°, or 4.9° above normal; the highest was 68°, at Fort Washakie on the 7th, and the lowest, 34° below zero, at same station on the 31st. The average precipitation was 0.44, or 0.21 below normal; the greatest monthly amount, 1.18, occurred at Fort Yellowstone, while none fell at Hyattville.—*W. S. Palmer.*

SPECIAL CONTRIBUTIONS.

THE CIRCULATORY MOVEMENTS IN THE ATMOSPHERE.

By Prof. V. BJERKNES.

In the MONTHLY WEATHER REVIEW for October, 1900, pp. 434–443, we have given the complete translation of a memoir by Prof. V. Bjerknes in which he explains in the most elementary manner his excellent ideas as to the geometrical treatment of a general dynamic principle applicable to the movements of the atmosphere. Possibly some of our readers will appreciate the further elucidation of this subject that has just been published by Bjerknes in reply to criticisms by a European student. We have, therefore, prepared the following collection of extracts from Bjerknes' article in the Meteorologische Zeitschrift for November, 1900, pp. 481–491, omitting some matters that are not essential to the proper understanding of his explanations.—ED.

The term gradient is now applied in meteorology to a series of quantities of very various physical significations. But all these quantities have certain common mathematical peculiarities corresponding to the meaning of this word. The gradients are all *directed* quantities, or vector quantities, whose distribution in space can be described by means of a system of surfaces. Along each surface of this system of surfaces a certain nondirected or scalar quantity has a constant value, and corresponding to this property we designate these surfaces by an additional word that is formed from the name of the scalar quantity itself with the prefix iso- or equi-[1]. The gradient is everywhere directed perpendicularly to these surfaces, and shows the direction and the amount of the greatest rate of change in that scalar quantity, which is constant in the direction of the (iso-) or (equi-) surfaces.

It is customary to give the corresponding gradient the same name as that of the scalar quantity. As a typical example, we may consider the temperature. This scalar quantity is constant along the isothermal surfaces. The temperature gradient or the thermal gradient is directed perpendicular to these surfaces and shows the direction and the amount of the greatest fall of temperature.

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I request the readers of my previous memoir to recall that I have used the word gradient only in the sense of the barometric gradient.

For the sake of greater clearness and in order to deduce some general properties of these vector quantities, I will write out the general hydrodynamic equations of motion. If x, y, z are the coordinates of any given particle of fluid, U_x, U_y, U_z are the component velocities, and, consequently,

$$\frac{dU_x}{dt}, \frac{dU_y}{dt}, \frac{dU_z}{dt}$$

are the component accelerations corresponding to these, then the equations of motion can be written in the following simple form, where p is the pressure, q the density, and g, with its components g_x, g_y, g_z, is the exterior accelerating force acting upon each unit of mass of the fluid:

$$\begin{aligned} q\frac{dU_x}{dt} &= -\frac{\partial p}{\partial x} + qg_x \\ q\frac{dU_y}{dt} &= -\frac{\partial p}{\partial y} + qg_y \\ q\frac{dU_z}{dt} &= -\frac{\partial p}{\partial z} + qg_z. \end{aligned} \tag{1}$$

In the case of atmospheric motions, g is the acceleration of gravity and qg the weight of a unit volume of air. On the right-hand side of these equations there also occur those components of the vector quantity about whose proper designation we have spoken, viz, the barometric gradient G, whose components are

$$\begin{aligned} G_x &= -\frac{\partial p}{\partial x} \\ G_y &= -\frac{\partial p}{\partial y} \\ G_z &= -\frac{\partial p}{\partial z}. \end{aligned} \tag{2}$$

On the other hand, by the space gradient Gr of Möller we must understand a vector quantity whose components along the axes are completely expressed by the right-hand members of the following equations:

$$\begin{aligned} Gr_x &= -\frac{\partial p}{\partial x} + qg_x \\ Gr_y &= -\frac{\partial p}{\partial y} + qg_y \\ Gr_z &= -\frac{\partial p}{\partial z} + qg_z. \end{aligned} \tag{3}$$

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The hydrodynamic equations (1) form the starting point of my study. I did not write them out in my previous memoir because I wished to give the demonstration the simplest possible elementary form; but, essentially, these equations did form my starting point, and since the right-hand sides of these equations are the three components of Dr. Möller's "space gradient Gr," therefore I have taken complete account of his vector quantity. It is no error, but rather a very important advantage that this vector does not appear in my result, for the vector Gr is in most cases a very awkward quantity to handle, and it would be difficult to make much advance by using it. In order to make this perfectly plain, I will repeat this portion of the proof in a purely analytical form. I first rearrange the equations (1), in that I divide throughout by the density, q, and then replace the density by its reciprocal, viz, the specific volume, or $k = 1/q$. Thus the equations become

$$\begin{aligned} \frac{dU_x}{dt} &= -k\frac{\partial p}{\partial x} + g_x \\ \frac{dU_y}{dt} &= -k\frac{\partial p}{\partial y} + g_y \\ \frac{dU_z}{dt} &= -k\frac{\partial p}{\partial z} + g_z. \end{aligned} \tag{4}$$

[1] According to the terminology introduced by Hamilton, and now generally used in mathematical physics, a quantity is said to be *scalar* when its value, at any point in space, can be expressed by a single number; typical examples are density, pressure, temperature, relative humidity, potential, etc. On the other hand, a quantity is said to be a *vector* quantity when three numbers are necessary in order to specify its value at any given point in space. The vector quantities have both magnitude and direction, the three numbers referred to are their components; typical examples are velocity, acceleration, force, and all quantities that we call gradients.